Glasgow Naturalist 2006. Volume 24. Part 4. Pages 59-71 .

FROM GLASGOW TO THE STAR PIT AND STUTTGART: A SHORT JOURNEY AROUND THE WORLD'S LONGEST FISH

Jeff Liston

Graham Kerr Building, Division of Environmental and Evolutionary Biology,
Faculty of Biomedical and Life Sciences,
and
Hunterian Museum,
University of Glasgow, Glasgow, G12 8QQ

ABSTRACT

The Ferrier Fergusson family of Glasgow's West End are more commonly known for their connections to the Tennant family – Henrietta Fergusson and her cousin Margaret Galbraith both married the Tennant brothers who founded the chemical company in their name (Crathorne, 1973). But the sister of Henrietta, Mary Ferrier Fergusson (or 'Ferry' as she was known to her family), married Alfred Nicholson Leeds of Eyebury near Peterborough, who was to become the single collector of the most extensive collection of Jurassic marine reptiles ever. As well as supporting and tolerating the invasion of Alfred's hobby into their living space, Mary also assisted him with the reconstruction of the often fragmentary fossil remains. Her efforts are in particular noted, with regard to the tail of the bony fish *Leedsichthys problematicus* (named in Alfred Leeds' honour), which it took them some nine months to glue together from its thousands of excavated fragments (Leeds, 1956). Following Alfred's death in 1917, Mary requested that the remainder of his collection go to her native city, as part of the Hunterian Museum's collections. Included within the material acquired by the Hunterian from the Leeds family is a singularly complete specimen of the fish *Leedsichthys problematicus*, which currently forms the basis of a research project (in part financially supported by the Glasgow Natural History Society's Blodwen Lloyd Binns Bequest fund) into the osteology of this animal. After the commencement of this project, a new specimen was discovered near Peterborough, which has been included within the scope of this work. Nicknamed 'Ariston', this specimen is the first significant find of this animal in Britain in ninety years.

INTRODUCTION

The nineteenth century was a crucible for change. From historical assessments of ancient cultures, to philosophical viewpoints of the universe, many fields were being critically reassessed in the light of new understanding. Even within the Church, voices were raised questioning the literal truth of the Bible, in the controversial 1860 collection of 'Essays and Reviews' by a series of Anglican clerics and theologians (Blackmore & Page, 1989). New feats of engineering and industrialisation were similarly paralleled by changes in theories of the natural world – advances in microscopy had led to new studies and understanding of biological tissues (Liston & Sanders, 2005). The expanding science of palaeontology was starting to pose awkward questions about the natural world in terms not only of the mutability of species, but also of the extinction of species – something that did not sit comfortably with the majority of people's religious beliefs, and their perception of the Great Chain of Being. The cautious assertion by individuals in the eighteenth century that some animals had become extinct (Rolfe, 1985), had led to the instinctive strivings of Chevalier de Lamarck's *Philosophie Zoologique* (Lamarck, 1809) and Robert Chambers' *Vestiges of the Natural History of Creation* (Chambers, 1845). But these ideas were finally cogently expressed in Darwin's *On the Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (Darwin, 1859). Darwin had been berated for the lack of a fossil example of an intermediate animal between two groups (or 'missing link') to demonstrate his theory of organic evolution 'in action' in the fossil record – but within three years the London specimen of *Archaeopteryx* had been revealed to the world, appearing to provide just what Darwin was lacking (Liston, 2000). Increasingly, the scientific world appeared to be moving towards a worldview that had no need of recourse to a deity working towards a 'grand plan', 'intelligent design' or 'final cause'.

Although it received little coverage at the time, the public debate between Archbishop Wilberforce ('Soapy Sam') and Thomas Henry Huxley on 30th June 1860 at the British Association for the Advancement of Science meeting in Oxford has subsequently come to be seen as symbolic of some of the wrenching changes that the Victorian world was going through at the time. In attacking Darwin's work, Wilberforce is alleged to have sarcastically asked Huxley if he was descended from an ape on his maternal or paternal grandparent's side – after countering Wilberforce's objections, Huxley then accused the Archbishop of prostituting his gifts of eloquence in order to undermine a serious scientific discussion: for a clergyman to be taken so publicly to task was indeed a sign that Science was in the ascendancy (Blackmore & Page, 1989). The debate seems to have signalled a shift in focus away from extinction to questions of descent. And as a symbol of the struggle that society was undergoing, the debate has a deeper resonance than that, for the foundations of its venue (the debate was the public inauguration of a building – the Oxford University Museum - paid for, somewhat ironically, with surplus funds from the University Press's Bible account! (Thomson, 2000)) were sunk deep into the Oxford Clay – one of the most highly vertebrate rich fossil sediments of the British Isles, replete with the remains of extinct animals awaiting discovery.

THE OXFORD CLAY

To the northeast of Oxford, but still within this same rich fossiliferous sediment, was a geographical area in which great surges in knowledge of ancient animal life were to be symbiotically linked with parallel industrial development - the Fenland around Peterborough. It began with an auctioned sale of land around Fletton (just south of Peterborough) – 400 acres were sold on 23/6/1877, and a series of individuals from a diverse group of trades decided to try their hand at producing bricks from the 'brick clay' of this land. Within four years, it had been noted that the deeper clay of the Peterborough area (the Lower Oxford Clay, lying beneath the superficial callow clay more traditionally dug) had an extremely high organic content, which meant that no additional coal or carbon was needed to be imported to fire the bricks – in essence, this 'clay that burns' was self-firing, and in removing the need for the additional expense of shipping in coal for the kilns, Fletton bricks became significantly cheaper, and thus hugely popular. It was this that changed the trend of clay digging from being a small-scale (often family-based) seasonal business, to a large-scale year round industrialised process. This meant that even more land around Peterborough came up for sale, and the landscape was swiftly transformed, with forests of kiln chimneys strewn across the landscape. Although initially excavated by hand with teams of men wielding 2 metre crowbars, this gradually gave way with the rise in demand from 1890 to industrial machinery and mechanical excavators, which more or less dominated the few pits that remained active during the Great War (Hillier, 1981).

By and large, it is essential for human (rather than mechanised) diggers to be employed to dig the clay, in order to observe fossils as they appear and prevent them from being destroyed during clay excavation - as noted by the renowned palaeontologist W. E. Swinton (in the foreword to Leeds, 1956). From this point of view, the optimum historical period for retrieval of fossils, is defined by the peak period of clay excavation following the realisation that the Lower Oxford Clay is an exceptionally useful for brick manufacture (circa 1881), until the time that the industry switches to being fully mechanised, around the end of the war (Leeds, 1956). Throughout this period, one key figure was abroad in Peterborough, collecting the marine fauna from the Jurassic seabeds represented by the Oxford Clay. He had collected such material in earlier years prior to large-scale excavation, and now he was poised to take advantage of the wealth of new material being uncovered every day by the armies of clay diggers now employed in the region. His name was Alfred Leeds.

ALFRED NICHOLSON LEEDS AND MARY FERRIER FERGUSSON

On Tuesday 19th October, 1875, a marriage took place at 11, Grosvenor Terrace (Fig. 1), Glasgow, between the young daughter of city merchant Alexander A. Fergusson, and Alfred Nicholson Leeds Fig. 2), a gentleman farmer living on the fens east of Peterborough. Mary Ferrier Fergusson was embarking on a wedded relationship with a man destined to become one of the world's greatest collectors of fossil Jurassic reptiles. She would also be, in equal part, a preparator and conservator of the bones of these animals from the Middle Jurassic Oxford Clay. In the twenty fifth year of their marriage (as recorded by the second of their five sons, Edward Thurlow Leeds (Leeds, 1956)), they spent nine months in cleaning and gluing together the many thousands of fragments that made up the tail of what was certainly the largest ever bony fish, *Leedsichthys*, named in honour of her husband (Fig. 4). Her palaeontological contribution thus went far beyond the perhaps typical one of the wife of a palaeontologist in the nineteenth century, because beyond simply tolerating the array of drawers of bones strewn around the many rooms of their house in Eyebury (Fig. 3) (east of Peterborough) while they were being worked on by her husband, she was an active supporter and collaborator in his work. Indeed, when Alfred Leeds died on the 22nd August 1917, it became necessary for the family to leave Eyebury soon after, and so she took a hand in the final disposal of the last accumulation of his collection, expressing the wish to Thurlow Leeds that the remainder of the collection of her dead husband (some 450 marine reptile specimens), pass into the care of the University of Glasgow, her native city. This led to the University of Glasgow's Hunterian Museum becoming the owner of the largest collection of Jurassic reptiles from a single collector in Britain, second only in size to the British Museum (Natural History), London.

This was a prodigious achievement: although the British Museum had, during Alfred's lifetime, been the main beneficiary of his collecting, having first refusal on any of the material that he found, most of the material that the British Museum had declined had passed through the hands of the dealer Stürtz of Bonn (between 1897 and 1911), to spread not simply throughout Europe, but around the globe (Leeds, 1956). The Hunterian's acquisition of this final bulk component of his collection meant that, in numerical terms at least, the Hunterian held the largest single collection of Alfred Leeds' material in the world. By the time of this purchase, the Hunterian Museum, along with the rest of the University of Glasgow, had moved from its Old College city centre site into Glasgow's West End, some 5 minutes walk from where Alfred and Mary had married, in Mary's family's home of 11, Grosvenor Terrace, at the head of Byres Road. This meant that for any future trips she made to see her family in Glasgow, the Museum holding the collection from over twenty five years of her late husband's collecting, would be near at hand to visit – and indeed the Hunterian Museum's visitor books record one of her visits on the 21st September 1915.

Prior to this final sale, however, some connections had already existed between Alfred Leeds and the University of Glasgow. A few modest batches of fossil material had already been bought from Leeds by Professor John Walter Gregory (see Fig. 5), the Head of the Geology Department. Gregory appears to have first come into contact with the Leeds Collection when he started work as an Assistant in the Geology Department of the British

Museum (Natural History) in 1887 (Longwell, 1933), during the period in which the initial bulk purchase ('The First Collection') from Alfred Leeds was arriving in that establishment (Leeds, 1956). Gregory later became the first incumbent of the Chair of Geology at Glasgow University in 1904. With that post came the Honorary Curator-ship in Geology for the University's Hunterian Museum, and it was after this that he arranged the purchases for the Hunterian's collections. Included within these were a remarkably complete skeleton of the ichthyosaur *Ophthalmosaurus*, (assembled by Assistant Curator William Robert Smellie, Fig. 6, so that it was on display in the Hunterian Museum from around 1916 until the 1970s, see Fig. 7), and what later turned out to be the most complete specimen of *Leedsichthys* ever collected (Liston, 1999). Now nicknamed 'Big Meg' (Fig. 8), this specimen was first noted by Alfred Leeds in a letter to Arthur Smith Woodward in February 1913 (Leeds, 1913) (Fig. 9, Fig. 10), and was sold to the University of Glasgow in February 1915 (Liston, 2004). Given that Alfred Leeds had traditionally offered first refusal of all his specimens to the British Museum (Natural History) in London, it may seem strange that the BM(NH) did not take the opportunity to purchase this specimen, as it consisted of more than twice the quantity of material as their holotype specimen (BMNH P6921), but archival documentation in the NHM appears to indicate that they had bought a substantial specimen from Alfred Leeds some fifteen years earlier – a specimen that now (despite its size) cannot be entirely confidently located (Liston, 2004; Liston & Noè, 2004). In the light of this, it is perhaps understandable that the BMNH might have let this particular fish 'get away' to Glasgow.

'Meg' is currently the core specimen of a research project based at the University of Glasgow, investigating the virtually undescribed osteology of *Leedsichthys*. To support this research, virtually all known specimens of this taxon have been loaned to Glasgow, a loan that was made financially possible through a generous grant from the Glasgow Natural History Society's Blodwen Lloyd Binns Bequest. The bones of this animal are renowned for being extensive, crushed, broken and fragmentary. In 1889, Arthur Smith Woodward made tentative attempts to understand its skull osteology (Woodward, 1889a, 1889b, 1890), but admitted eight years later that beyond the fin-rays of the tail and the seven and a half centimetre long gill rakers, that no bone had been satisfactorily identified (Leeds & Woodward, 1897). It is believed, because of the unsegmented and bifurcating nature of the fin rays in its tail, that this fish is a member of the Family Pachycormidae. Indeed, in 1916 (Woodward, 1916), Arthur Smith Woodward himself stated with some excitement that he could see a resemblance to *Leedsichthys* bones "in miniature" in the 1.5 metre long specimen of the pachycormid *Saurostomus* from the Holzmaden shale (BMNH P11126, Fig. 11). Arguably the best collection of Jurassic fossil fish specimens lie in the museums in Germany with substantial material from the Holzmaden Posidonienschiefer or lower Jurassic shale of southern Germany, and so a collection visit to these museums (again, generously supported by a grant from the Glasgow Natural History Society's Blodwen Lloyd Binns Bequest) became an essential part of the study.

Why try to see a large number of specimens, as opposed to one well-preserved individual? There are a number of reasons why a comprehensive attempt to see as many specimens as possible of this family of bony fishes would be vital to understanding the skeletal anatomy of *Leedsichthys*, but the central one is this: the skull bones of these pachycormids are so thin and interlock and overlap to such a degree, that individual bones (such as remain of *Leedsichthys*) are extremely hard to discern: it is no surprise that if one looks at the smaller but apparently related genus of *Saurostomus* from the Holzmaden shales that its skull bones are like silk handkerchiefs, so thin that it is hard to tell which bone is lying on top of which (Fig. 12). It is thus only through examining specimens showing skulls in widely differing degrees of disarticulation, that individual bones (and their origins within the overall scheme of the skull) can be determined. Thus, after a few interesting hints from other institutions across Germany (in particular in München and Tübingen), it was of little surprise that the most important clues to the identities of some of the giant skull bones of *Leedsichthys* came from the remarkable Staatliches Museum für Naturkunde in Stuttgart, with its many specimens of both *Pachycormus* and *Saurostomus* from the Holzmaden shale. For the first time, as a result of this examination, it was clear that bones extremely similar to the maxillary (Fig. 13) and dentary (Fig. 14) bones of *Saurostomus* were present in large form in some of the remains of *Leedsichthys* (Fig. 15, 16).

But a more direct aid to the understanding of the skeletal anatomy of *Leedsichthys* had also come to light in the interim.

LEEDSICHTHYS - A NEW SPECIMEN

In July 2001, I received a bone through the post. Not an entirely unusual event in itself, this bone would turn out to be something quite special. It had been found by a Portsmouth Palaeobiology undergraduate (Martill, 2002), working in one of the many brick pits around Peterborough that excavate the Oxford Clay to manufacture bricks (Dawn, 2004). The student, Marcus Wood, had come across the bone protruding from a face that had not been worked by the shale planer since the early nineteen eighties. Another student on the course, Matt Riley, looked at the face independently, and saw a number of smaller bones protruding from the same bed. Fortunately, their course supervisor, Dr. David M. Martill, was also, in collaboration with Dr. Colin Adams of the Institute of Biomedical and Life Sciences, University of Glasgow, co-supervising my postgraduate research on the gigantic Jurassic fish *Leedsichthys*, and so knew to send the bone to me for identification. I was able not only to confirm his suspicion that it was indeed *Leedsichthys*, but also to state that it was likely to be a dorsal fin spine, of the kind mistakenly identified by the German palaeontologist Von Huene as being a tail spine belonging to the stegosaurian dinosaur *Omosaurus* (now *Lexovisaurus*) (Huene, 1901) (see Fig. 17).

The Star Pit at Whittlesey (coincidentally one that Alfred Leeds had himself collected from some 90 years before) was coming to the end of its working life, producing clay for the Hanson Brick Company to turn into bricks. This meant that if a dig were to be organised, it could be run without the health and safety issues surrounding the excavation of material in the same pit as active shale planers, which could prove potentially dangerous. Dr. Martill and myself made plans, and eventually visited the site on the 22nd October 2001, together with Alan Dawn of the Peterborough City Museum, to assess the significance of the find and the potential of the site. We had mixed results from the assessment – on the positive side, we could confirm that, as Matt Reilly had indicated, there were 13 small bones projecting from the cliff, over an 8.5 metre stretch of the same layer (Bed 14 (Hudson & Martill, 1994)) as the one that had yielded the longer dorsal fin spine (Fig. 18). Given the range in sizes of the projecting bones, and that the remains seemed relatively concentrated for a fish estimated to grow anywhere from 10 (Woodward, 1917) to potentially 27.6 metres (as hinted at in the case of one exceptional partial set of remains (Martill, 1986)), it seemed that little transportation or disruption to the skeleton had occurred. This appeared to indicate that a major find, as large as any specimen so far recovered, was hidden within the cliff. On the negative side, an excavation could not be conducted particularly far into a bed with 20 metres of overburden with very much safety. And given the size of the fish, both Dave and I knew that it was likely that a substantial area of the cliff would have to be removed to be confident that we had a chance of recovering everything that we both felt might well be there. It was clear that this would require a heavy piece of excavating machinery, and this would not be cheap to hire. In the worst possible case scenario, we might end up spending a large amount of money to remove a cliff some 20 metres (50 feet) in height, only to find that the fragments that we could see the ends of, were all that was left of the fish – the rest having been removed in the early 1980s and turned into bricks perhaps used for a bathroom extension in Norfolk in the nineteen eighties. But this seemed the least likely result. What was virtually certain was that we had the most significant find of this fish since (according to Natural History Museum archives) February 1913 (Leeds, 1913), and what was extremely likely was that within the cliff was probably the most complete specimen of the fish ever found.

What made attempting to excavate the specimen all the more worthwhile, was that one had never been excavated under the rigour of full scientific procedures, with mapping of the remains before they came out of the ground. The closest to mapped indications of how the bones of *Leedsichthys* had been found, were some doodled sketches contained in a letter from the collector Alfred Leeds to Arthur Smith Woodward of the British Museum (Natural History) in London (Leeds, 1898), and a rough scale-less site map made up retrospectively by a group of German teenagers (as well as Peterborough, the remains of the fish have also been found in Normandie, northern Germany, and Chile) analysing fifteen years worth of photographs that they had taken during their digs (Probst & Windolf, 1993; Michelis *et al.*, 1996). Even if we did prove to be misguided in our expectations of the completeness of this new specimen, the value of the first properly mapped record of the bones of *Leedsichthys* as found, could be immeasurable.

The rarity of such an opportunity was too great to pass on, and by May 2002 Dr. Martill had raised the initial funding for a 2-week dig, led by myself, scheduled for the following month. Dr. Martill would have led the dig himself, but for his intensive work schedule for that summer. Personally, my schedule was also busy - I had a long-planned tour of collections in Germany booked for July - but given the quantity of bone likely to be excavated (based on the quantity of material comprising the most complete specimen currently known, the specimen nicknamed 'Big Meg' in the University of Glasgow's Hunterian Museum), the planned two weeks would be adequate for the excavation necessary. Unfortunately, paperwork problems delayed our starting date, so that the heavy excavator, a 21 tonne Komatsu, could only get access to the site starting on the 24th June (Martill & Liston, 2003). It took fully five days for the extremely skilled driver, Dave Peppercorn, to remove the 20-metre overburden from a roughly 25 metre by 9-metre area of the bed (Fig. 19). He was able to strip the clay beds back to a yellow shell bed layer some 8cm above the bone level (Dawn, 2002), shifting some 10,000 tonnes of material in the process, some of which went to form a platform and slope that our volunteer diggers would later use to work on.

The sky was darkening when the Komatsu excavator finally left the site at the end of that first week, its job done (Fig. 20). I remained to guard the dig over the weekend, to ensure that no opportunistic collectors tried to scavenge material from an abandoned site, while Dr. Martill went to collect his undergraduate volunteer diggers from Portsmouth University for the following Monday morning. I was able, in the fresh 8am daylight of that first Saturday morning, to go down to the newly exposed bed, start to excavate from the edge of the cliff, and take stock of what we actually had. I will never forget that initial period of excavation, seeing the enormous density of bone, far in excess of what we had seen protruding from the edge, and way beyond our expectations. It was clear that we had at least one very completely preserved section of this fish (Fig. 22). Some faulting within the cliff (resulting from slippage of the cliff after being worked by the shale planer in the early eighties) meant that the bone might be limited to that first area (Fig. 21), but still the quantity of bone recovered had already made the expenditure on the excavator worthwhile.

Two days into the following week, I was already running behind schedule for my planned departure for the collection study trip (including the valuable and successful visit to Stuttgart, mentioned earlier). Despite my reluctance to leave the dig at this early stage, it was clear that I had to go. Dr. Martill would take over as acting dig leader in my absence, and despite our joint expectation that everything would soon be finished, he gave me an undertaking that if some well-preserved and associated skull material started appearing, he would ensure that it was left and not lifted until I had returned and seen it in place. But we were both wrong. When I returned three weeks later, bone was still being exposed, with little sign yet of anything that might be skull material, or an end to the bone material being revealed. The problem was not the usual one on digs, of difficulty in finding bone, but that 'too much' bone was being found – often diggers would complain about how they yearned for areas of clay devoid of bone, so that they knew that at least in one area they had come to an end of the preserved remains. The problems of excavating the material had grown over the days that I had been away. Contrary to appearances when the bed was first cleared, the topography of the clay layer did undulate slightly – and an incautious hand could accidentally go through bone, especially as some elongated rod-like components seemed to be long enough to lie proud of the soft clay layer that the bulk of the bone was held within, so that it projected into the harder slabs of the overlying bed. These topographical problems were compounded by a degree of faulting criss-crossing through the bed that had become apparent when the shell bed had been removed during early hand excavation. Although these faults did not appear to run directly through many bones, and the throw was not too significant (it was never too far from the broken end of one part of a bone to its matching broken surface in an opposing block), this still added complications which might again lead unwary excavators to accidentally excavate through bone. There was a core area of bone that ran in an area about 14 metres by 8, and within that there were many areas that were multi-layered, so that after one layer of bone had been exposed, mapped on to large plastic sheets and removed, another layer came to light. This was particularly problematic and time consuming in an area christened 'Green Bay' (named after the couple that dedicatedly excavated it, Peter and Margaret Green, of the Stamford Geological Society) that was densely filled with gill rakers, and ultimately this could only be resolved by removing roughly 7cm deep slabs of the area, in the hope of full excavation at a later date in laboratory facilities. Also problematic was the bone itself, which baffled seasoned excavators of Oxford Clay reptiles with over twenty years experience, who were entirely unprepared for a fossil animal with so many bones that were often so thin and delicate, yet sometimes exceptionally large and always incredibly fragile. This caused particular problems when trenching around some of the larger bones for plaster jacketing, as there would often be dozens of smaller bones lying around the perimeter, which could unwittingly be destroyed by the incautious digger. The clay needed to be pared away from the bones using dental tools - painstaking and time consuming, but the only way to safely release the bones from this matrix. Traditional methods of applying Paraloid B72 conservation glue had to be distinctly refined – although one could get away with applying thick mixes of this substance to reptile bone in the field, with this fossil fish, the glue simply obliterated the bone and made it extremely difficult to lift from the clay. And yet, in contrast, if the bone did not receive Paraloid B72 very soon after being exposed to the air, it would desiccate and start to break down within a couple of days. This was a particularly significant problem in the first few weeks of the dig when large areas of bone were being exposed faster than they could be protected, and the weather was fluctuating between intense heat and heavy downpours of rain, which alternately baked and flooded the site (see Figs. 23-25).

Although all of these factors were part of an elaborate learning curve for all involved, they also meant that, in conjunction with the quantity of bone being way in excess of what was predictable from existing material, they massively increased the amount of time that the dig took. The new specimen of *Leedsichthys* soon acquired the nickname of 'Ariston', because it simply went 'on and on' (as the old commercial advertisement used to declare). This unpredictability in terms of quantity of material meant that numbers of people available to dig dwindled when the largest amount of bone had to be lifted – after the 26th July, the core team dropped to just three individuals as dedicated diggers on the site. Eventually, the site had to be closed on Thursday 26th September, not because all the bone had been removed, but for two rather more pragmatic reasons. Firstly, the university term was about to commence, which mean that the diggers (both students and staff) needed to return to their various institutions. Secondly, the Hanson Brick Company needed the Portakabin back that they had kindly lent us over the summer in order that we could store the collected specimens in. Both of these factors meant that it was time for the site to be evacuated for that field season. A nine tonne truck was hired for the mammoth job of transporting all of the many hundreds of clay and plaster blocks into more long term storage (Fig. 26).

In August 2003, a small group of diggers reassembled at the Star Pit, to clear the rest of the bones from the exposed bed, for three reasons: firstly to ensure that there was no opportunity for individuals to plunder bones from the bed after the broadcast (planned for a month later) of a television programme reporting the exceptional find (Dawn, 2004); secondly to assess the degree to which bones were continuing into the cliff, and whether it was therefore worth removing more of the cliff in the hope of retrieving more of the same specimen; and thirdly to ensure that should it prove necessary to bring back a heavy digger to take the cliff back further, that there would be no danger that bones left in place on the excavation bed would be damaged by the digger returning. For two weeks, these individuals laboured to clear the remainder of the bone, supported by the Palaeontological Association and the National Museums of Scotland, within a small window of time formed by the availability of individuals to work without jeopardising their own summer project work. The work was made hard by the impact of winter weather, which had homogenised the upper strata, making it difficult to distinguish and separate them during excavation – the 'pen-knife' excavation beloved of the previous year was no longer possible. Following this, the onset of summer had reduced the surface layers to fine flakes of shale, which was difficult to remove cleanly. By the end, the site had been cleared to a degree satisfactory to the diggers, and plans were in place for removal of the cliff. It is planned that, depending on the availability of myself or Dr. Martill, the cliff removal will not take place until the start of the next field season (2006) – partly so that further bones will be secured safe from potential private collectors within the cliff, and partly because the environmental protection of 20 metres of clay on top of a bed is invaluable: a fresh bed relatively unaffected by weather will be considerably easier to work than one which is exposed to the rigours of the Fens winter.

What have we learned from this remarkable fish specimen (registered with Peterborough City Museum as PETMG F174) – a discovery already described as the most important British vertebrate fossil find since the dinosaur *Baryonyx* was excavated in 1983? The specimen is exceptional in a number of important respects, including quantity of material (over 2,300 bones collected by the end of the 2003 field season, see Fig. 27), the presence of paired bones for the first time in a specimen of *Leedsichthys*, and remarkable clarity of skeletal growth structures on many of its bones, from gill-rakers to hyomandibulae and fin rays. Some of these growth structures superficially resemble growth rings, which hold out some promise of yielding growth data for this animal. With great optimism, Dr. Martill and myself had hoped for some sign of stomach contents as an indicator of diet: the fish has long been regarded as an edentulous suspension feeder like a baleen whale or a basking shark, in part because of its unusually large (over 7.5cm in length) gill-rakers in the absence of any teeth, but some preserved evidence from its gut would help to remove any ambiguity over this. It rapidly became clear that the component of the skeleton that had been preserved within the cliff would not contain this region of its body (that appears to have ended up as part of the aforementioned hypothetical Norfolk bathroom extension), but some small fish vertebrae were preserved within the central mass of gill rakers, which might serve as an indicator of some of the prey items that *Leedsichthys* (perhaps inadvertently) fed upon (see Fig. 28).

In addition to the retrieved remains themselves, and of equivalent importance, is the documentation – a detailed series of plastic mapping sheets (roughly 6 x 2 metres each – see Fig. 29), paper maps, field notes and a host of digital images, all of which make it possible to recreate the disposition of the bones as they were originally found.

Funding is currently being sought for the Herculean task of preparing the bone out of the clay slabs collected – an estimated task of one and a half person years in duration, to fully clean the more than 2,000 bones thus far collected. In the interim, Alan Dawn, the bone plasterer *par excellence* of Peterborough City Museum and Stamford Geological Society, has been working at cleaning occasional bones, but as a part-time volunteer it is slow and arduous work, at a rate of approximately a dozen every three months – a sign of both the scale of the problem, and the difficulty of the work (Fig. 30). Particularly problematic will be the preparation of the most fragile and complex structures, the pectoral fins (Fig. 31), currently embedded in robust plaster jackets and layers of B72 glue (Fig. 32).

It is clear that there is much more of Ariston's bony remains still in the Star Pit, and hopefully funding can also be raised to remove a little more of the cliff (which the skull remains seem to be heading into) and resume the dig armed with an informed and realistic schedule, and a full complement of diggers.

CONCLUDING REMARKS

Alfred Leeds remains a pioneering figure from the nineteenth century 'bone rush' of vertebrate palaeontology. As a single collector, the quality and quantity of his excavated material (in March 1894, just four years after selling his entire collection to the British Museum (Natural History), his newly formed collection was insured with the Insurance Company of North America for £1,000), and its worldwide distribution, is without peer. He personally found no difficulty in reconciling his theological beliefs with Science. Indeed, in a lecture he gave to local people at Glinton School one spring, he criticised 'religious instructors' for failing to keep up to date: "Religion must work with & keep up with science."

We sit at the start of the 21st century, and look back at how much we have learned in the last 150 years. Yet with all our increases in knowledge and understanding, it is humbling to realise how little we have moved forward: as lowly a vertebrate as a fish, whose fossil remains were first described well over a hundred years ago, is little better understood today than it was at the end of the nineteenth century; the recent rise in Christian Fundamentalism has forced creationism back into the school classrooms of the USA and Europe, through the supernatural doctrine of 'intelligent design' (Brumfiel, 2005; Gewin, 2005). A hundred years ago, Alfred Leeds described the cause of the problem as being that the "negligence of churches in not keeping up with [the] times [is the] cause of much unbelief [and] too much going back to the ignorant beliefs, forms, and superstitions of [the] middle ages." Although in many areas, hugely significant progress has been made since the Victorian era, in others, the progress seems a lot harder to discern.

ACKNOWLEDGEMENTS

Many people have helped in the progress of this project. Firstly, those individuals who have given access to key specimens in public collections: not only Alison Longbottom, Peter Forey and Sandra Chapman of the Natural History Museum (London), but also Ronald Böttcher (Stuttgart), Bettina Reichenbacher (München), Ronald Winkler and Ulf Linnemann (Dresden), Gunther Viohl (Eichstätt), Gloria Arratia & Hans-Peter Schultze (Humboldt Museum, Berlin), Lothar Schöllmann and Christina Reimann (Münster). Secondly, those that financed and supported the tour of collections abroad, and the transportation of specimens on loan – in particular the Blodwen Lloyd Binns Bequest Fund of the Glasgow Natural History Society, Jon Jeffery and Donna Saxby as well as Alison Brown.

The dig for Ariston itself had some direct financial benefactors, who have often gone unsung - palaeontological digs rely heavily on the enthusiasm and effort of volunteers, but this excavation was extremely fortunate in being financially supported by a number of bodies, primarily through the gratefully appreciated approaches of Dave Martill - without whom, the dig simply could not have happened. NERC's emergency funding route, and the Aggregate Levy's Sustainability Fund are particular contributors, but the major funder, helping both field seasons (in particular to cover the costs of hiring excavating machinery from R&R Plant Hire, with the highly skilled Dave Peppercorn), was the Palaeontological Association. Other contributors were English Nature, the Stamford Geological Society, the East Midlands Geological Society, and the Friends of Peterborough Museum. The owners of the Star Pit at Whittlesey – Hanson Brick – gave us fantastic hospitality and access to essential facilities as well as the permission to excavate Ariston, and Andy Mortlock was a stalwart point-of-contact. Further help in kind was in particular provided by the Hunterian Museum (University of Glasgow), the National Museums of Scotland and also by the University of Portsmouth - but the most significant contributor in this respect was all the diggers, who gave their time for no remuneration whatsoever - making a total of over 3,000 working hours in the pit over both field seasons. Special mention and thanks go to Tom Challands and Kay Hawkins in this regard. Sarah Earland, Peter and Margaret Green gave particular specialist expertise to the dig. Nick Watts and Adeline Ramage tried hard to make the filming as painless as possible, which was appreciated. Dave Martill has kindly allowed the reproduction of some of the images used in this article.
Special thanks to Julian and Louis Leeds for access to their family's archives, and Rosie Wyndham (née Leeds) for photograph sourcing. Susan Snell, Polly Tucker and Karen Taylor's help in guiding myself and Leslie Noé through the NHM's correspondence archive is gratefully acknowledged.
Finally, appreciation is expressed to John Wagner and Carlos Ezquerra for coming up with the 'Big Meg'.

INSTITUTIONAL ABBREVIATIONS

GLAHM = Hunterian Museum, The University of Glasgow, Scotland.
SMN ST = Staatliches Museum für Naturkunde in Stuttgart, Germany.
BMNH = Natural History Museum (London), England.
PETMG = Peterborough Museum and Art Gallery, Cambridgeshire, England.
CAMSM = Sedgwick Museum of Geology, Department of Earth Sciences, University of Cambridge, England.

REFERENCES

Blackmore, V. & Page, A. 1989. *Evolution The Great Debate*. Lion Publishing plc, Oxford.
Brumfiel, G. 2005. Who has designs on your students' minds? *Nature*, **434**, 1062-1065.
Chambers, R. 1845. *Vestiges of the Natural History of Creation*. John Churchill, London.
Crathorne, N. 1973. *Tennant's Stalk: The Story of the Tennants of the Glen*. Macmillan, London.
Darwin, C. 1859. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. John Murray, London.
Dawn, A. 2002. The Year of the Fish *Leedsichthys problematicus*. *Musings* [33], 1-2. 1-12-2002. Peterborough, Friends of Peterborough Museum and Art Gallery.
Dawn, A. 2004. *Leedsichthys problematicus*. *Geology Today*, **20**, 53-55.
Gewin, V. 2005. Scientists attack Bush over intelligent design. *Nature*, **436**, 761-761.
Hillier, R. 1981. *Clay That Burns: A History of the Fletton Brick Industry*. London Brick Company Limited, London.
Hudson, J.D. & Martill, D.M. 1994. The Peterborough Member (Callovian, Middle Jurassic) of the Oxford Clay Formation at Peterborough, UK. *Journal of the Geological Society*, **151**, 113-124.
Huene, F.V. 1901. Notizen aus dem Woodwardian-Museum in Cambridge. *Centralblatt für Mineralogie, Geologie und Paläontologie*, **1901**, 715-719.
Lamarck, J. B. P. A. de M. 1809. *Philosophie Zoologique ou Exposition des Considerations relatives a l'Histoire Naturelle des Animaux*. Chez Dentu, Paris.
Leeds, A.N. Letter from Alfred Nicholson Leeds to Arthur Smith Woodward. Woodward, A. S. 18-3-1898.
Leeds, A.N. Letter from Alfred Nicholson Leeds to Arthur Smith Woodward. Woodward, A. S. 28-2-1913.
Leeds A.N. & Woodward, A.S. 1897. Report on a Field-trip to Peterborough. *Proceedings of the Geological Association*, **15**, 190-192.
Leeds, E.T. 1956. *The Leeds Collection of Fossil Reptiles*. Oxford.
Liston, J. J. 2000. *Archaeopteryx* and the evolution of feathered flight: the hidden story. *Quarterly Journal of the Dinosaur Society*, **4 (1)**, 6-14.
Liston, J.J. 1999. Dicynodonts, brick-pits, and hunting for that first dinosaur: the Mesozoic vertebrates in the museums of Scotland. *Dinosaur World* **6**, 55-57.
Liston, J.J. 2004. An overview of the pachycormiform *Leedsichthys*. In: *Mesozoic Fishes 3 - Systematics, Paleoenvironments and Biodiversity*. (Ed. by G. Arratia & A. Tintori), pp. 379-390. Verlag Dr. Friedrich Pfeil, München.
Liston, J.J. & Noè, L.F. 2004. The tail of the Jurassic fish *Leedsichthys problematicus* (Osteichthyes: Actinopterygii) collected by Alfred Nicholson Leeds - an example of the importance of historical records in palaeontology. *Archives of Natural History*, **31**, 236-252.
Liston, J. J. & Sanders, H. L. 2005. The 'other' Glasgow Boys: the rise and fall of a school of palaeobotany. In: *History of Palaeobotany: Selected Essays*. (Ed. by A. J. Bowden, C. V. Burek, & R. Wilding), pp. 197-228. Geological Society, London.
Longwell, C.R. 1933. Memorial tribute to John Walter Gregory. *Bulletin of the Geological Society of America*, **44**, 414-415.
Martill, D.M. 2002. A Very Big Fish. *Planet Earth* , 4-7.

Martill, D.M. 1986. The world's largest fish. *Geology Today*, March-April, 61-63.
Martill, D.M. & Liston, J. J. 2003. Big Gamble for a Big Dead Fish. *The Palaeontological Association Newsletter.* [52], 40-43.
Michelis I., Martin Sander P., Metzdorf R. & Breitkreuz, H. 1996. Die vertebratenfauna des Calloviums (Mittlerer Jura) aus dem Steinbruch Störmer (Wallücke, Wiehengebirge). [The Callovian (Middle Jurassic) vertebrate fauna of the Störmer Quarry (Wallücke, Wiehengebirge).]. *Geologie und Paläontologie in Westfalen*, **44**, 5-66.
Probst E. & Windolf, R. 1993. *Dinosaurier in Deutschland.* Bertelsmann, München.
Rolfe, W. D. I. 1985. William and John Hunter: breaking the Great Chain of Being. In: *William Hunter and the Eighteenth Century Medical World.* (Ed. by W. F. Bynum & R. Porter), pp. 297-319. Cambridge University Press, Cambridge.
Thomson, K. S. 2000. Huxley, Wilberforce and the Oxford Museum. *American Scientist* **88**: 210-212.
Woodward, A.S. 1889a. Notes on some new and little-known British Jurassic Fishes. *Annals and Magazine of Natural History*, **Series 6, Volume 4**, 405-407.
Woodward, A.S. 1889b. Preliminary notes on some new and little-known British Jurassic fishes. *Geological Magazine*, **Decade III Volume 6**, 448-455.
Woodward, A. S. 1890. Notes on some new and little-known British Jurassic fishes. Report of the fifty-ninth meeting of the British Association for the Advancement of Science. 585-586. John Murray, London.
Woodward, A.S. 1916. On a new specimen of the Liassic pachycormid fish *Saurostomus esocinus*, Agassiz. *Geological Magazine*, **Decade VI Volume 3**, 49-51.
Woodward, A.S. 1917. Alfred Nicholson Leeds, F.G.S. *Geological Magazine*, **Decade VI Volume 4**, 478-480.

PLATES AND FIGURES

PLATE 1.

FIGURE 1. Number 11, Grosvenor Terrace, in Glasgow's West End, around the time when Mary's family lived there, at the end of the nineteenth century. The house was only a few minutes walk away from the University of Glasgow's Hunterian Museum. Photograph used by courtesy of the Mitchell Library, Cultural & Leisure Services, Glasgow City Council.

FIGURE 2. Alfred Nicholson Leeds and Mary Ferrier Fergusson, together in a Peterborough photographic studio, around 1875. Image courtesy of Julian Leeds. Copyright resides with the Leeds Family.

FIGURE 3. The Leeds family home at Eyebury. Image courtesy of Julian Leeds, from the unpublished manuscript 'Eyebury and the Leeds collection', 1938/9.

FIGURE 4. The tail (BMNH P.10,000) of *Leedsichthys problematicus*, as displayed in 1937 (NHM-ESL negative number 1660). The span of the tail is 2.74 metres. Thurlow Leeds recalled why it took some nine months to reassemble the "thousands of pieces" of the tail collected: "a packet of fragments representing a length of 3 or 4 inches, and belonging possibly to two original rays, contained on the average (in the slenderer parts) 120 fragments" (Leeds, 1956). By permission of the Trustees of The Natural History Museum (London).

FIGURE 5. Professor John Walter Gregory, Chair of Geology (1904-1929) in the University of Glasgow, and Honorary Curator in Geology for the Hunterian Museum. Photograph © Hunterian Museum, University of Glasgow.

FIGURE 6. Dr. William Robert Smellie, Assistant Curator in Geology, circa 1915. He worked extensively on reconstructing the marine reptiles of Alfred Leeds bought for the Hunterian Museum. Reproduced with kind permission of Valerie Boa, with whom copyright resides.

FIGURE 7. The mounted skeleton of *Ophthalmosaurus icenicus* (GLAHM V1070), as displayed in the Hunterian Museum from about 1916-1966. Picture probably taken between 1916 and 1920 by S. Finland. Photograph © Hunterian Museum, University of Glasgow.

FIGURE 8. The full extent of 'Big Meg' (specimen GLAHM V3363), laid out in a corridor of the Hunterian's main research store. John Faithfull (1.8m) is included for scale.

FIGURE 9. The bone sketched by Alfred Nicholson Leeds in his letter to Arthur Smith Woodward. It is a component of specimen GLAHM V3363 ('Big Meg'). Bone is a 77cm long preopercle.

FIGURE 10. Extract from a February 1913 letter from Alfred Nicholson Leeds to Arthur Smith Woodward, enquiring about a bone of *Leedsichthys* that he had found. (NHM-GL DF100/55/468). By permission of the Trustees of The Natural History Museum (London). Copyright resides with the Leeds Family.

PLATE 2

FIGURE 11. *Saurostomus esocinus* (BMNH P11126), 1.3 metres long.
FIGURE 12. Detail from the skull of BMNH P11126 (field of view is 11cm wide).
FIGURE 13. Skull of SMN ST 52472, clearly showing outline of maxillary.
FIGURE 14. Skull of SMN ST 50736, clearly showing outline of dentary.
FIGURE 15. Maxillary of 'Big Meg' (GLAHM V3363).
FIGURE 16. Dentary of 'Big Meg' (GLAHM V3363).
FIGURE 17. The first bone of 'Ariston' (PETMG F174) – sent for identification after excavation from the Star Pit in 2001. Below is a piece of *Leedsichthys* identified by Friedrich Von Huene in 1901 as a stegosaurian tail-spine (CAMSM J.46873).
FIGURE 18. The *Leedsichthys* locality in the Star Pit. Alan Dawn and David Martill stand next to the quarry face, indicating the 8.5 metre distance over which bone was found on 22nd October 2001. David Martill (right) is pointing at the horizontal bed that the bone was emerging from. A yellow 'X' between them marks where the first bone sample was retrieved from the bed by Marcus Wood.
FIGURE 19. The Komatsu excavator, driven by Dave Peppercorn, obliterating the 20 metre high cliff sitting on top of the fish. © D. M. Martill.

PLATE 3.

FIGURE 20. The author views the newly exposed bed, prior to manual excavation commencing, on 29th June 2002. © D. M. Martill.

FIGURE 21. First excavated area, showing slippage 'fault' to left. Margaret Green for scale. © D. M. Martill.

FIGURE 22. Reconstruction of *Leedsichthys* as an 18 metre fish by Bob Nicholls (September 2003), with line to show the portion of the body (to the left) thought to be contained within the cliff. © Bob Nicholls, Palaeocreations (www.paleocreations.com).

FIGURE 23–25. The site regularly flooded (23) and required to be pumped out (24) before excavation could continue (25).

FIGURE 26. Fish-van: the nine tonne truck filled with plaster jackets containing the bones of the fish. In the foreground is a Channel 4 filmcrew.

PLATE 4.

FIGURE 27. Peter Green's map of the site: each cross marks the corner of a 1 metre square grid, designed and constructed by him, that was utterly invaluable for accurately recording the site. For simplicity at this scale, only the largest components have been included. © Peter Green, 2002.

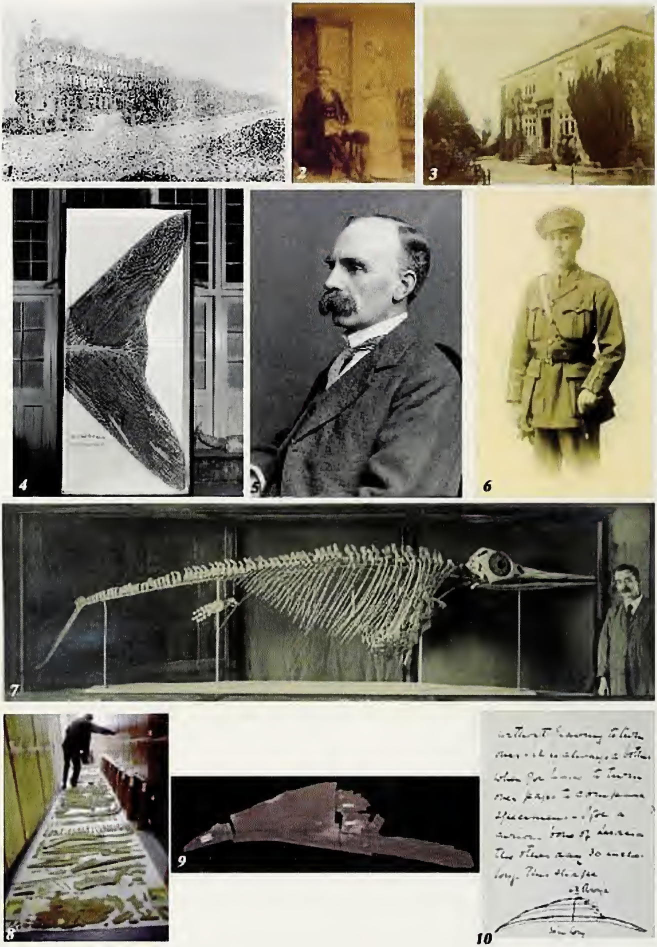
FIGURE 28. Sketch by Bob Nicholls (August 2004) to indicate the indiscriminate ingestion of an extremely large suspension-feeding Jurassic fish. © Bob Nicholls, Palaeocreations (www.paleocreations.com).

FIGURE 29. Unrolling one of the 18 plastic mapping sheets created to map the finds during the two field seasons. Peter Green (orange hard hat) directs operations. © D. M. Martill.

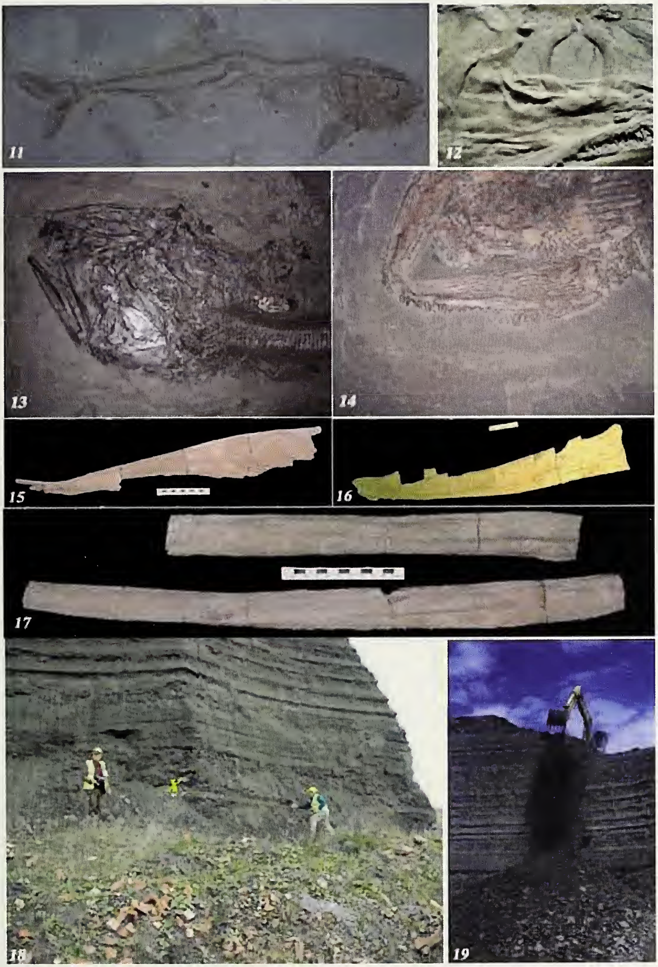
FIGURE 30. A handful of the more than 2,300 bones retrieved from the Star Pit site. These have been prepared out of their clay matrix by Alan Dawn, of the Peterborough City Museum.

FIGURE 31. The right pectoral fin of Ariston (PETMG F174/10,002), pedestalled prior to being jacketed in plaster for removal. © D. M. Martill.

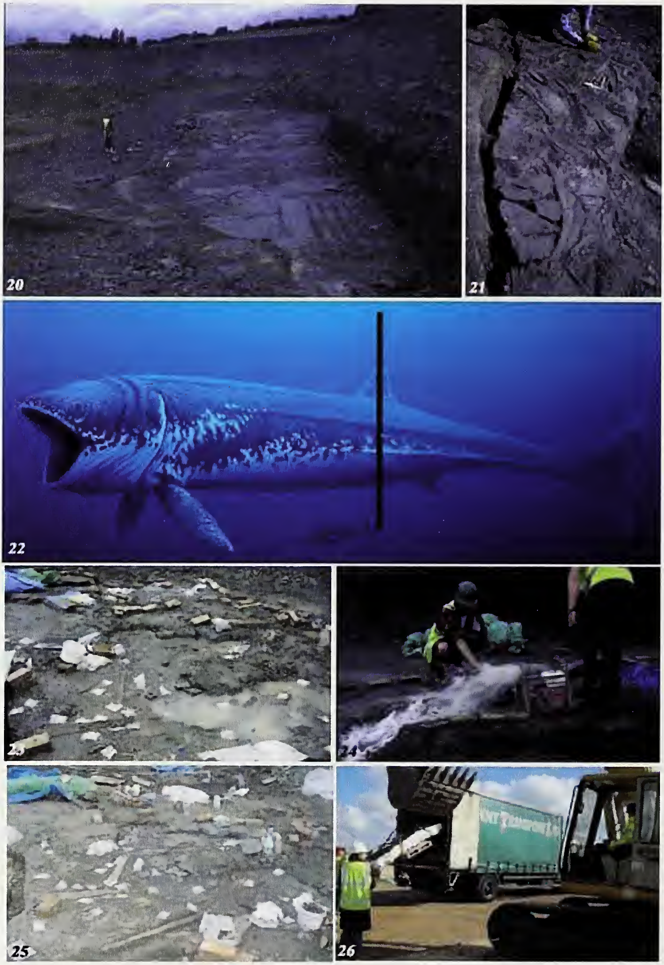
FIGURE 32. The left pectoral fin (with overlying dermal bones, PETMG F174/10,025) hoisted into the air on the last day of the first field season. © D. M. Martill.



Liston. Plate 1.



Liston. Plate 2.



Liston. Plate 3.

Liston Plate 4.